A manufacturing method of a joint panel includes: joining an outer panel to an inner panel by applying an adhesive to an outer edge of the outer panel; performing electrodeposition coating on a surface of the outer panel of the joint panel in which the outer panel is joined to the inner panel; and burning, onto the outer panel, a coating film formed on the surface of the outer panel by the electrodeposition coating. The adhesive used herein is a room temperature curing adhesive that does not flow at the time of the burning.
FIG. 1

APPLY ADHESIVE TO OUTER EDGE

HEMMING PROCESS

DRY ADHESIVE

ELECTRODEPOSITION COATING

BURNING OF COATING FILM
FIG. 5
MANUFACTURING METHOD OF JOINT PANEL

INCORPORATION BY REFERENCE


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The present invention relates to a manufacturing method of a joint panel in which an outer panel made of a metallic material is joined to an inner panel made of a material having a linear expansion coefficient different from a linear expansion coefficient of the metallic material.

[0004] 2. Description of Related Art
[0005] In recent years, a panel such as a hood for an automobile has been manufactured as a joint panel in which an outer panel made of a metallic material is joined to an inner panel made of a material different from the metallic material. Aluminum alloy or a steel sheet such as high tensile strength steel is used as the metallic material of the outer panel, and a metallic material different from the outer panel, or a fiber reinforced plastic is used as the material of the inner panel.

[0006] The outer panel and the inner panel are made of different materials, so their linear expansion coefficients are different from each other. Because of the linear expansion coefficients, peeling of adhesion may occur due to shear stress (thermal stress) caused on adhesive surfaces. In view of this, Japanese Patent Application No. 2007-118852 (JP 2007-118852 A) proposes such a manufacturing method of a joint panel that an outer panel is fixed to an inner panel by adhesion, and a bracket is fixed by adhesion, to both the inner panel and the outer panel so as to cover at least part of an outer-panel outer-edge side of the inner panel from an outer edge of the outer panel.

[0007] Even if the peeling of adhesion is caused by shear stress (thermal stress) caused on the adhesive surfaces due to a difference between the linear expansion coefficients of the outer panel and the inner panel, it is possible to prevent the outer panel from falling off the inner panel by the bracket.

[0008] However, generally, the adhesive that bonds the outer panel to the inner panel is applied at the time when the outer panel and the inner panel are assembled, and after that, the adhesive is cured at the time when a coating film deposited by electrodeposition coating is burned onto the outer panel. Accordingly, when the coating film is burned, the outer panel is stretched in a range of elastic deformation due to heat of the burning, and in such a stretched state, the outer edge of the outer panel is restricted by the inner panel through the adhesive thus cured.

[0009] Consequently, the outer edge of the outer panel to be deformed to contract (restore) by cooling (standing to cool) after the coating film is burned is restricted by the inner panel through the cured adhesive, so that the deformation of the outer panel at the time of the burning is maintained. This may impair an appearance of the outer panel.

SUMMARY OF THE INVENTION

[0010] The present invention provides a manufacturing method of a joint panel, which manufacturing method can restrain deformation of an outer panel at a room temperature even in a case where coating/burning is performed on a surface of the outer panel in a state where outer edges of the outer panel and an inner panel are bonded via an adhesive.

[0011] A manufacturing method of a joint panel, according to one aspect of the present invention includes: joining an outer panel made of a metallic material to an inner panel made of a material having a linear expansion coefficient different from a linear expansion coefficient of the metallic material by applying an adhesive to either one of an outer edge of the outer panel and an outer edge of the inner panel and curing the adhesive; performing electrodeposition coating on a surface of the outer panel of the joint panel in which the outer panel is joined to the inner panel; and burning, onto the outer panel, a coating film formed on the surface of the outer panel by the electrodeposition coating, wherein the adhesive is a room temperature curing adhesive that does not flow at the time of the burning.

[0012] According to one aspect of the present invention, the room temperature curing adhesive is used when the outer panel is joined to the inner panel in the joining, so that the outer panel is joined to the inner panel by curing the adhesive without causing heat to act on the outer panel and the inner panel, thereby forming the joint panel.

[0013] The joint panel thus obtained is subjected to electrodeposition coating in the coating, and further, when the coating film is burned onto the outer panel in the burning, thermal stress temporarily acts on the outer panel due to a thermal expansion difference between the outer panel and the inner panel.

[0014] However, in the burning, the adhesive does not flow, so that the adhesive is maintained in a cured state. Accordingly, even if the outer panel is cooled off to a room temperature after the burning and the outer panel contracts, the thermal stress acting on the outer panel is removed. Hereby, the outer panel returns to its original shape, so that appearance of its coating surface is not impaired.

[0015] As such, in the joint panel after the burning, shear stress caused due to thermal stress hardly acts on adhesive surfaces of the outer panel and the inner panel at a room temperature, so that it is possible to secure reliability of the outer panel and the inner panel with the adhesive.

[0016] Particularly, in a case where the adhesive is provided to seal inner sides of the outer panel and the inner panel, its sealing characteristic can be secured. This makes it possible to restrain corrosion of the outer panel made of the metallic material.

[0017] Note that the “room temperature curing adhesive” is an adhesive that is cured only by natural drying without heating, so as to adhere two members. A two-component room temperature curing adhesive is generally known as the room temperature curing adhesive.

[0018] The metallic material of the outer panel may be aluminum alloy, and the material of the inner panel may be a fiber reinforced plastic. A linear expansion coefficient of the aluminum alloy is extremely larger than a linear expansion coefficient of the fiber reinforced plastic. Because of this, in a case where the aluminum alloy is used for the outer panel and the fiber reinforced plastic is used for the inner panel, a thermal expansion difference therebetween in the burning is larger than combinations of other materials. However, the adhesive is maintained in a cured state as described above, so it is possible to restrain deformation of the outer panel after the burning. Hereby, it is possible to sufficiently achieve a
design property that the outer panel using aluminum alloy originally has, the design property is a design property based on coating glossy.

[0019] At the time of the joining, a hemming process may be performed such that the adhesive is applied to the outer edge of the outer panel, and the outer edge of the outer panel is folded toward the outer edge of the inner panel.

[0020] The adhesive is placed between the outer edge of the outer panel and the outer edge of the inner panel in the hemming process. Hereby, it is possible to prevent overflow of the adhesive. Further, even if the adhesive is peeled off at the time of the burning, the inner panel does not fall off the outer panel, because the outer edge of the inner panel is accommodated in a folded part (the outer edge) of the outer panel.

[0021] The adhesive may be a two-component epoxy adhesive. Hereby, it is possible to reduce surface deflection, which is a displacement amount of the joint panel after the burning.

[0022] According to one aspect of the present invention, it is possible to restrain deformation of an outer panel at a room temperature even in a case where coating/burning is performed on a surface of the outer panel in a state where outer edges of the outer panel and an inner panel are bonded via an adhesive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

[0024] FIG. 1 is a view illustrating each step to manufacture a joint panel according to an embodiment of the present invention;

[0025] FIG. 2 is a schematic perspective view illustrating an outer panel and an inner panel;

[0026] FIG. 3 is a schematic perspective view illustrating the joint panel in which the outer panel is joined to the inner panel;

[0027] FIG. 4 is a schematic sectional view illustrating a hemming structure of outer edges of the outer panel and the inner panel; and

[0028] FIG. 5 is a schematic perspective view to describe electrodeposition coating performed on a surface of the outer panel of the joint panel in which the outer panel is joined to the inner panel.

DETAILED DESCRIPTION OF EMBODIMENTS

[0029] The following describes an embodiment of the present invention with reference to the drawings. FIG. 1 is a view illustrating each step to manufacture a joint panel according to an embodiment of the present invention, and FIG. 2 is a schematic perspective view illustrating an outer panel and an inner panel. FIG. 3 is a schematic perspective view of the joint panel in which the outer panel is joined to the inner panel, and FIG. 4 is a schematic sectional view illustrating a hemming structure of outer edges of the outer panel and the inner panel. FIG. 5 is a schematic perspective view to describe electrodeposition coating performed on a surface of the outer panel of the joint panel.

[0030] First, an outer panel (an outer hood) 20 and an inner panel (an inner hood) 30 are prepared. The outer panel 20 is a panel made of aluminum alloy, which is a metallic material, and is a panel that is press molded in a shape illustrated in FIG. 2. Electrodeposition coating is performed on a surface of the outer panel 20 after the outer panel 20 is joined to the inner panel 30. In the present embodiment, the metallic material of the outer panel 20, aluminum alloy is used from the viewpoint of lightweighting of the panel, but a steel sheet may be used, for example.

[0031] The inner panel 30 is made of a material having a linear expansion coefficient different from a linear expansion coefficient of the metallic material. Examples of the material include a metallic material different from the outer panel 20, a resin material, a fiber reinforced plastic, and the like. The fiber reinforced plastic, which is a material having a lightweight and a high strength, is preferable among them.

[0032] The fiber reinforced plastic indicates a resin reinforced by a reinforcing fiber. The reinforcing fiber may be, for example, a fiber such as glass fiber, carbon fiber, aramid fiber, aluminia fiber, boron fiber, steel fiber, PBO fiber, or high-strength polyethylene fiber.

[0033] The resin may be a thermo setting resin or a thermo plastic resin, and examples thereof include epoxy resin, phenolic resin, melamine resin, urea resin, silicone resin, maleimide resin, vinylester resin, unsaturated polyester resin, unsaturated polyethylene resin, polyurethane resin, cyanate resin, and polyanime resins.

[0034] In the present embodiment, the resin having such a reinforcing fiber is molded into a shape illustrated in FIG. 2. From the viewpoint of low cost, the inner panel 30 is made of a sheet molding compound (C-SMC) in which carbon of a thermo setting resin is a reinforcing fiber.

[0035] First, in S11 of FIG. 1, an adhesive is applied to an outer edge 21 of the outer panel 20 thus prepared, and the inner panel 30 is superimposed on the outer panel 20, as illustrated in FIG. 2. The adhesive used herein is a room temperature curing adhesive that does not flow in the aforementioned step (a burning step) of burning a coating film.

[0036] Such an adhesive can be a two-component epoxy adhesive, and is preferably a two-component epoxy resin which includes a bisphenol-A epoxy resin, a bisphenol-F epoxy resin, a novolak epoxy resin, or the like as a base compound and which also includes an amine, polyamine, or mercaptan curing agent. The two-component epoxy resin may be a solventless resin, an organic solvent resin, or a water-based resin.

[0037] Then, in S12 of FIG. 1, a hemming process is performed with respect to the outer edge 21 of the outer panel 20 and an outer edge 31 of the inner panel 30, as illustrated in FIG. 3. More specifically, the outer edge 21 of the outer panel 20 is folded toward the outer edge 31 of the inner panel 30. Hereby, as illustrated in FIG. 4, the outer edge 21 of the outer panel 20 is placed so as to surround the outer edge 31 of the inner panel 30, and an adhesive 40 is placed between the outer edge 21 of the outer panel 20 and the outer edge 31 of the inner panel 30.

[0038] Then, in S13 of FIG. 1, the adhesive 40 is dried. In the present embodiment, the room temperature curing adhesive is used as the adhesive 40, so it is possible to join the outer panel 20 and the inner panel 30 by curing the adhesive without heating the outer panel 20 and the inner panel 30 (a joining step). Hereby, a joint panel 1 can be obtained.

[0039] Then, in S14 of FIG. 1, electrodeposition coating is performed on a surface 22 of the outer panel 20 of the joint
An outer panel (outer hood) made of aluminum alloy (JIS: 6000 series aluminum alloy) having a shape illustrated in FIG. 2, an inner panel (inner hood) made of a carbon fiber reinforced plastic (C-SMC), and an adhesive that is a two-component epoxy adhesive (a product made by LORD Far East Incorporated: Fusor320/310Black, containing a base compound and a curing agent by 1:1) are prepared.

Then, the two-component epoxy adhesive is applied to an outer edge of the outer panel, and a hemming process is performed so as to fold the outer edge of the outer panel toward an outer edge of the inner panel, as illustrated in FIG. 4. After that, the two-component epoxy adhesive is cured under conditions of 30°C. (room temperature) and 70 minutes. Then, electrodeposition coating is performed on a surface of the outer panel, and a coating film formed on the surface of the outer panel by electrodeposition coating is cured under conditions of a heating temperature of 180°C and a heating time of 20 minutes.

Images of an entire surface of a joint panel before and after the burning are taken, and on the basis of the joint panel before the burning, a displacement amount of the outer panel of the joint panel after the burning is measured. A result thereof is shown in Table 1. (A) to (F) shown in Table 1 indicate displacement amounts at respective measurement points shown in FIG. 3.

| Table 1 Displacement amount at each measurement point (mm) |
|---------------|---------------|---------------|---------------|---------------|---------------|
| (A)           | (B)           | (C)           | (D)           | (E)           | (F)           |
| Example 1     | -2.5          | 7.5           | -2.5          | 0.0           | -2.5          | -7.5          |
| Example 2     | -3.0          | 6.0           | -2.5          | 0.0           | -3.0          | -6.0          |
| Example 3     | -3.0          | 7.5           | -3.0          | 1.0           | -3.0          | -7.5          |
| Comparative   | -2.5          | 2.5           | -2.5          | 15.0          | -5.0          | -5.0          |

Example 2

A joint panel is manufactured in the same manner as Example 1. A point different from Example 1 is as follows: an adhesive that is a two-component epoxy adhesive (a product made by LORD Far East Incorporated: Fusor320/322, containing a base compound and a curing agent by 1:1) is used as an adhesive. Then, similarly to Example 1, images of an entire surface of the joint panel before and after the burning are taken, and on the basis of the joint panel before the burning, a displacement amount of an outer panel of the joint panel after the burning is measured. A result thereof is shown in Table 1.

Example 3

A joint panel is manufactured in the same manner as Example 1. A point different from Example 1 is as follows: an adhesive that is a two-component epoxy adhesive (a product made by LORD Far East Incorporated: Fusor390/391, containing a base compound and a curing agent by 1:1) is used as an adhesive. Similarly to Example 1, images of an entire surface of the joint panel before and after the burning are taken, and on the basis of the joint panel before the burning, a displacement amount of an outer panel of the joint panel after the burning is measured. A result thereof is shown in Table 1.
Comparative Example

A joint panel is manufactured in the same manner as Example 1. A point different from Example 1 is that a one-component epoxy adhesive is used as an adhesive, and a coating film formed on a surface of an outer panel by electrodeposition coating is burned and the adhesive is cured under conditions of a heating temperature of 180°C and a heating time of 40 minutes. Similarly to Example 1, images of an entire surface of the joint panel before and after the burning are taken, and on the basis of the joint panel before the burning, a displacement amount of the outer joint panel after the burning is measured. A result thereof is shown in Table 1.

<Result 1 and Consideration 1>

In a case of the joint panels of Examples 1 to 3, the adhesive is cured in advance by drying in the joining step, so that the outer panel elastically deformed by expansion in the burning step is restored to its original state after cooling. Accordingly, the displacement amount as a surface deflection at the joint (D) is smaller than that of the comparative example. In the meantime, in a case of the joint panel of the comparative example, the adhesive is cured at a point when the outer panel is elastically deformed by expansion in the burning step. As a result, the deformation is maintained, so that the displacement amount as a surface deflection at the joint (D) is larger than those of Examples 1 to 3.

Reference Examples 1 to 3

An aluminum alloy plate (JIS: 6000 series aluminum alloy) with 25 mm x 70 mm x 0.9 mm, corresponding to an outer panel, and a carbon fiber reinforced plastic plate (C-SMC) with 25 mm x 70 mm x 2.0 mm, corresponding to an inner panel, are prepared. The adheres according to Examples 1 to 3 are prepared as adheres for Reference Examples 1 to 3.

The aluminum alloy plate thus prepared is degreased by isopropyl alcohol (IPA), and the carbon fiber reinforced plastic plate is degreased by dry wipe. Then, these plates are dipped in rust preventive oil (a product made by Sugamin Chemical Industrial Co., Ltd., PRETON 303PX2), and left for 24 hours or more.

Each of the adheres is applied to the aluminum alloy plate and the carbon fiber reinforced plastic plate after the dipping, so that an adhesive thickness is 0.25 mm and an adhesion area is 25 mm x 12.5 mm, and the each of the adheres is cured under conditions of 30°C (room temperature) and 70 minutes. Then, a heating process corresponding to the burning step is performed at a heating temperature of 180°C for a heating time of 20 minutes.

In order to perform three-level measurement, in each test described below, on the joint panels in each of which the aluminum alloy plate is joined to the carbon fiber reinforced plastic plate through each of the adheres of Reference Examples 1 to 3, test pieces are prepared.

More specifically, a shear test (JISK6850) is performed under conditions of an elastic stress rate of 5 mm/min, a chuck-to-chuck distance of 90 mm, and a test temperature of 25°C, so as to measure a shear strength between the aluminum alloy plate and the carbon fiber reinforced plastic plate. A result thereof is shown in Table 2. Table 2 shows an average value of the shear strength measured three times for each of Reference Examples 1 to 3.

Further, a cross peel test is performed at an elastic stress rate of 5 mm/min and at a test temperature of 25°C, so as to measure a breaking strength between the aluminum alloy plate and the carbon fiber reinforced plastic plate. A result thereof is shown in Table 2. Table 2 shows an average value of the breaking strength measured three times for each of Reference Examples 1 to 3.

Furthermore, a breaking mode of the aluminum alloy plate in each of the tests is further observed. A result thereof is shown in Table 2. Note that, in Table 2, AF indicates an interfacial failure, CF indicates an adhesion cohesive failure, TCF indicates a thin layer adhesive cohesive failure, and respective values shown subsequently thereto each indicate an area ratio.

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shearing Test</td>
</tr>
<tr>
<td>Strength (MPa)</td>
</tr>
<tr>
<td>Reference</td>
</tr>
<tr>
<td>Example 1</td>
</tr>
<tr>
<td>Reference</td>
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<tr>
<td>Example 2</td>
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<tr>
<td>Reference</td>
</tr>
<tr>
<td>Example 3</td>
</tr>
<tr>
<td>TCF</td>
</tr>
</tbody>
</table>

<Result 2 and Consideration 2>

From the result of Reference Examples 1 to 3, in a case where the adheres of Reference Examples 1, 2 are used, a breaking ratio of the adhesion cohesive failure (CF) is large, so that it is considered that the aluminum alloy plate and the carbon fiber reinforced plastic plate are in a particularly good adhesion state.

The embodiment of the present invention has been described above, but the present invention is not limited to the above embodiment, and various design modifications can be made without departing from the spirit of the present invention described in Claims.

What is claimed is:

1. A manufacturing method of a joint panel, comprising:
   joining an outer panel made of a metallic material to an inner panel made of a material having a linear expansion coefficient different from a linear expansion coefficient of the metallic material by applying an adhesive to an outer edge of an outer edge of the outer panel and an outer edge of the inner panel and curing the adhesive;
   performing electrodeposition coating on a surface of the outer panel of the joint panel in which the outer panel is joined to the inner panel; and
   burning, onto the outer panel, a coating film formed on the surface of the outer panel by the electrodeposition coating, wherein
   the adhesive is a room temperature curing adhesive that does not flow at the time of the burning.

2. The manufacturing method of the joint panel, according to claim 1, wherein:
   the metallic material of the outer panel is aluminum alloy; and
   the material of the inner panel is a fiber reinforced plastic.
3. The manufacturing method of the joint panel, according to claim 1, wherein:
   at the time of the joining, a hemming process is performed such that the adhesive is applied to the outer edge of the outer panel, and the outer edge of the outer panel is folded toward the outer edge of the inner panel.
4. The manufacturing method of the joint panel, according to claim 1, wherein the adhesive is a two-component epoxy adhesive.